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The influence of sabot threads on the performance of KE penetrators

Nick Lynch, John Stubberfield: QinetiQ Ltd, Fort Halstead, UK

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Introduction

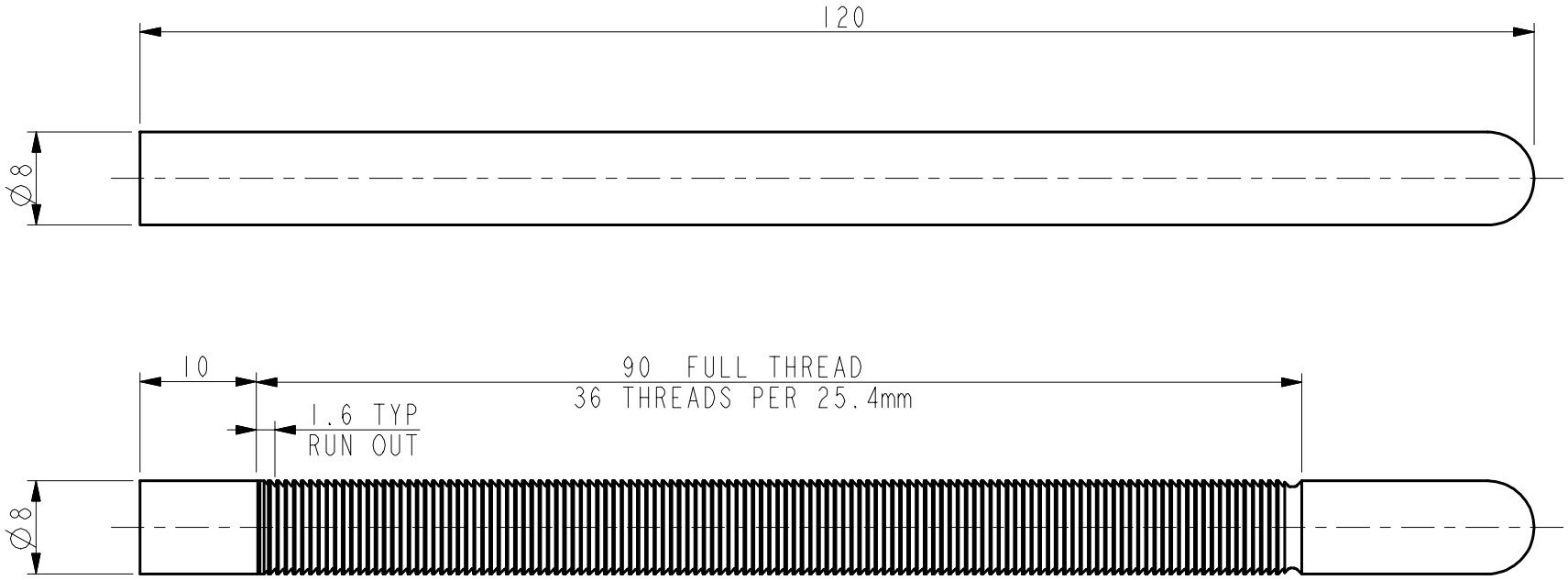
- The majority of fin stabilised, kinetic energy (KE) projectiles use threads along the interface with the sabot to launch the penetrator from the gun
- The threads are generally undesirable at impact on a target since the thread root forms a stress concentration
- If the number of threads could be reduced, would this improve penetration performance ?
- Are threads needed in hydrocode simulations of impact events and a possible cause of discrepancies between experiment and simulation ?

Scope of the work

- Forward ballistic tests (40mm calibre)
  - Four designs of L/D 15 penetrator
  - Two types of multi-plate target
  - 1600 m/s
- Reverse ballistic tests (40mm calibre)
  - Two designs of L/D 30 penetrator
  - Oblique plate target fired at pitched attitude penetrators
  - 1650 m/s

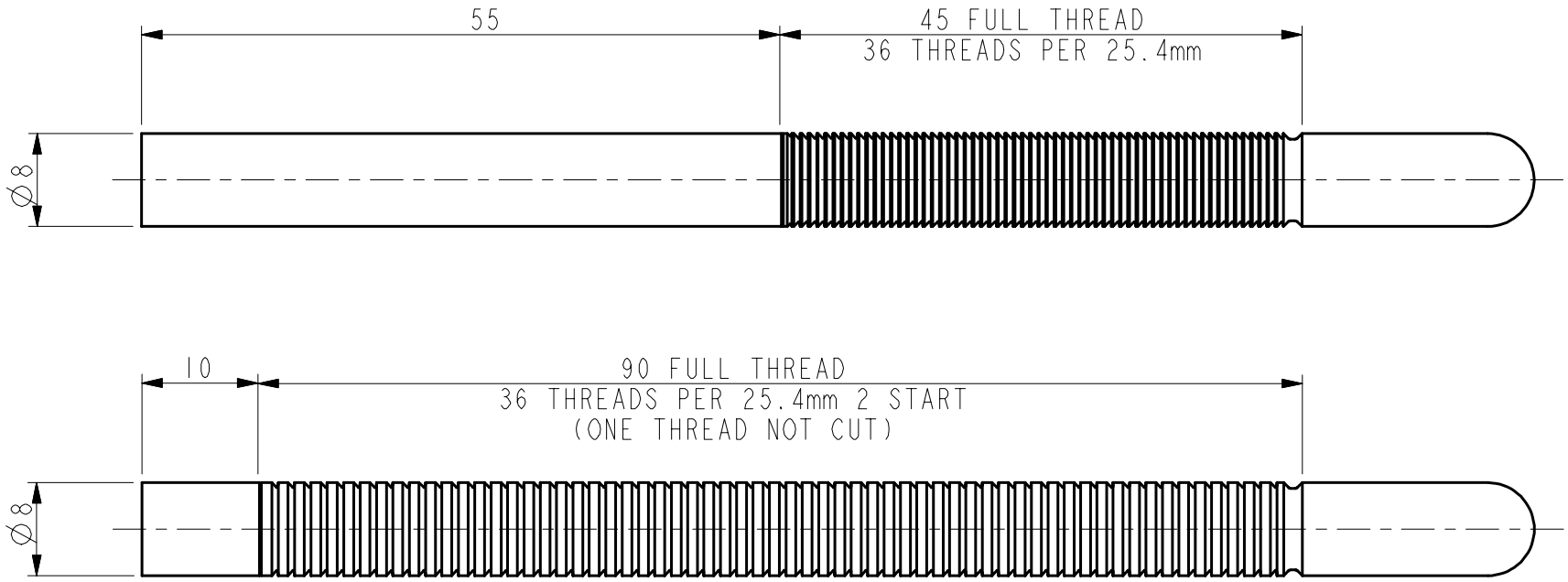
Projectiles

- Plain finish and full thread

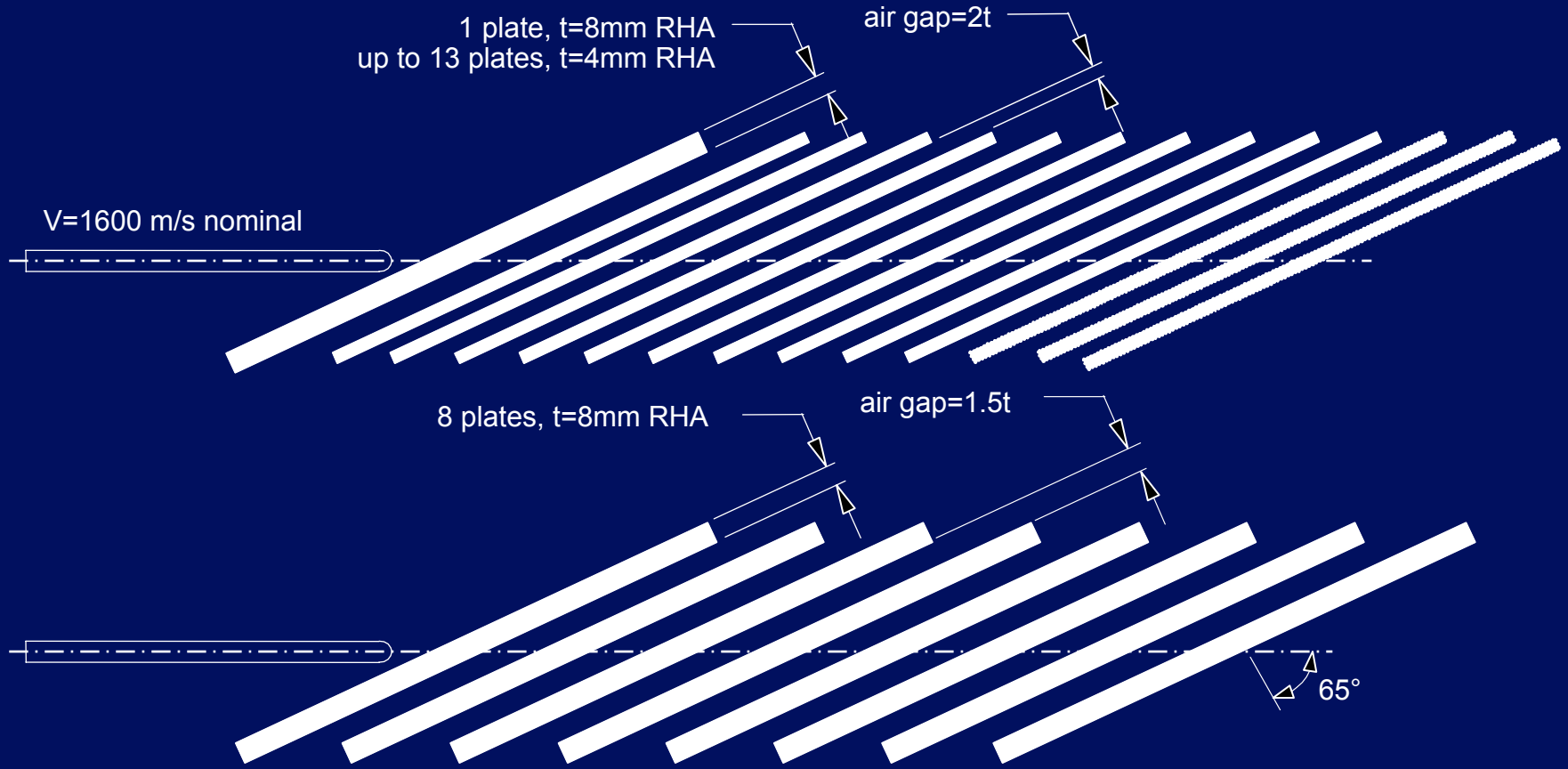


Projectiles

- Half thread and double thread

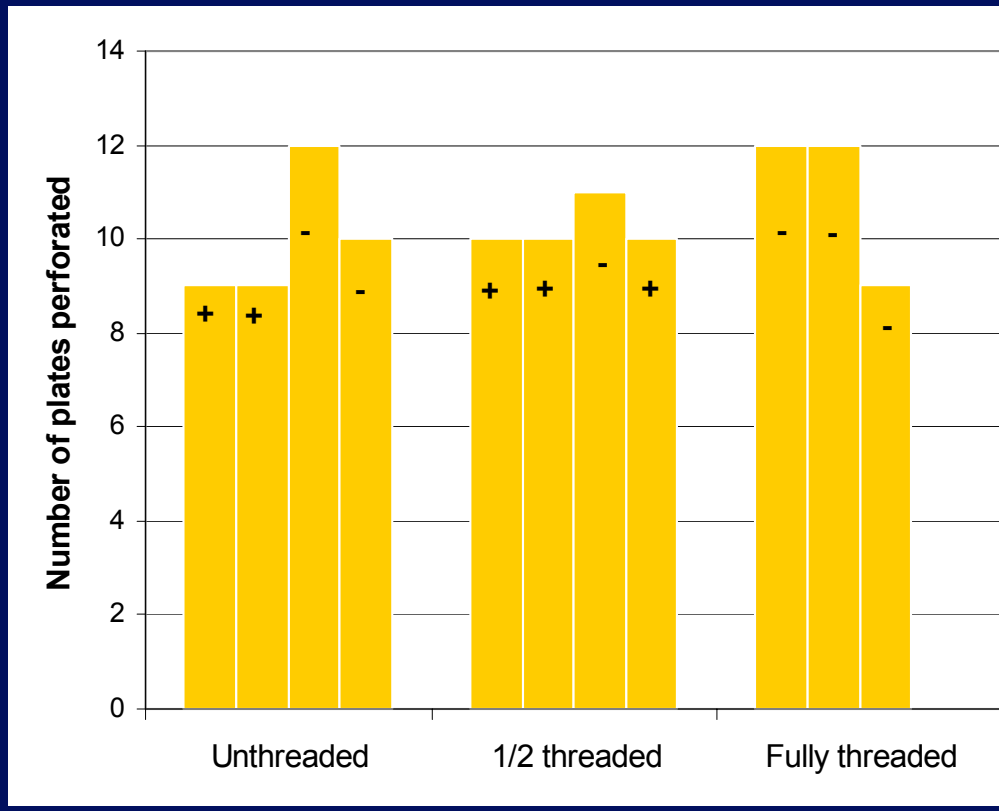


Target designs

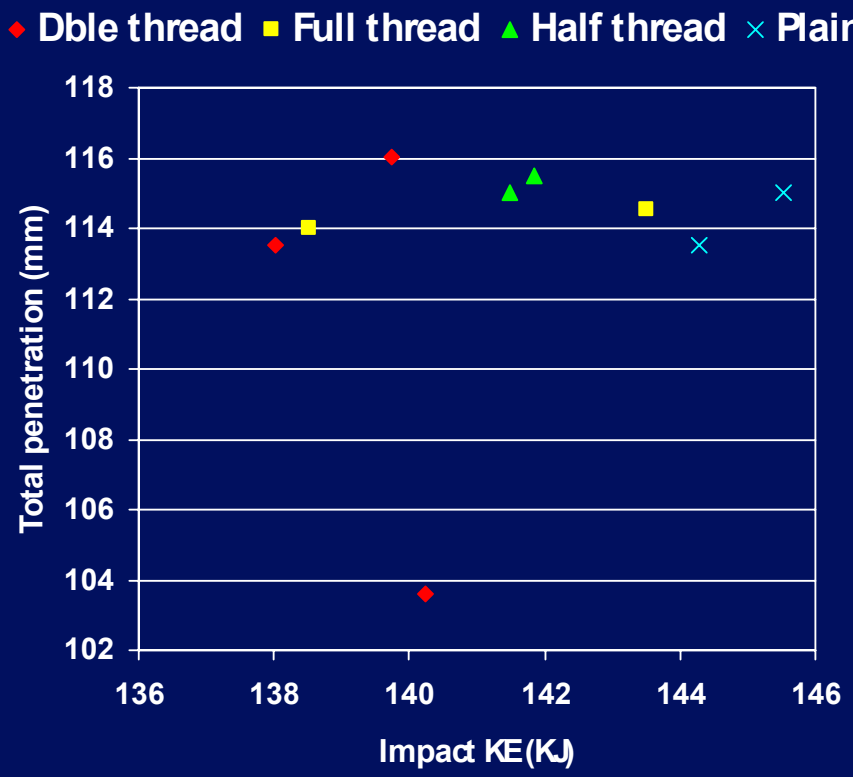


Results against Target 1

- 3 rod types tested
- Assessment of results made difficult by variation in impact pitch angle
- The results can be ranked by pitch
- Allowing for this, no apparent difference in penetration

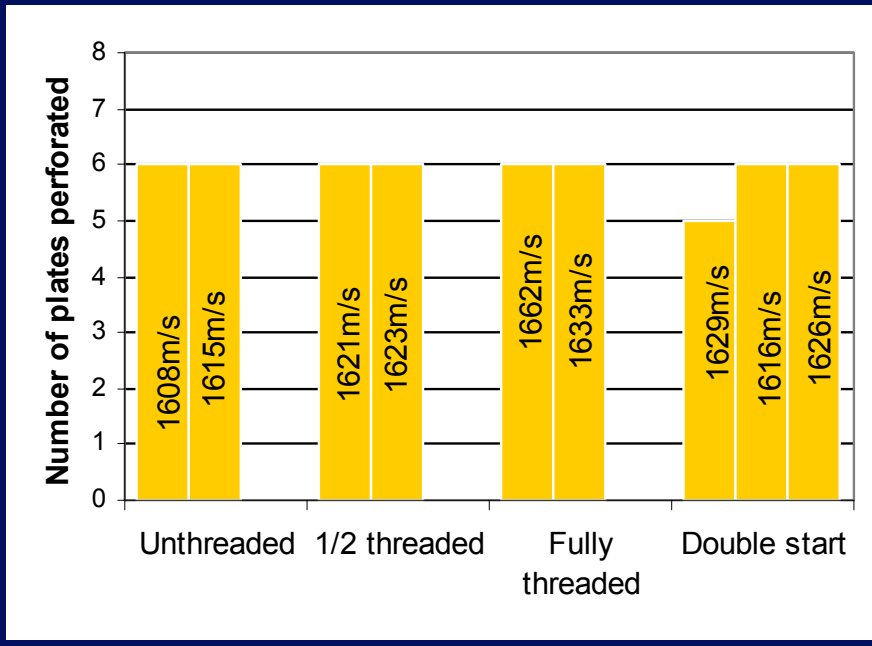


Penetration into Target 2



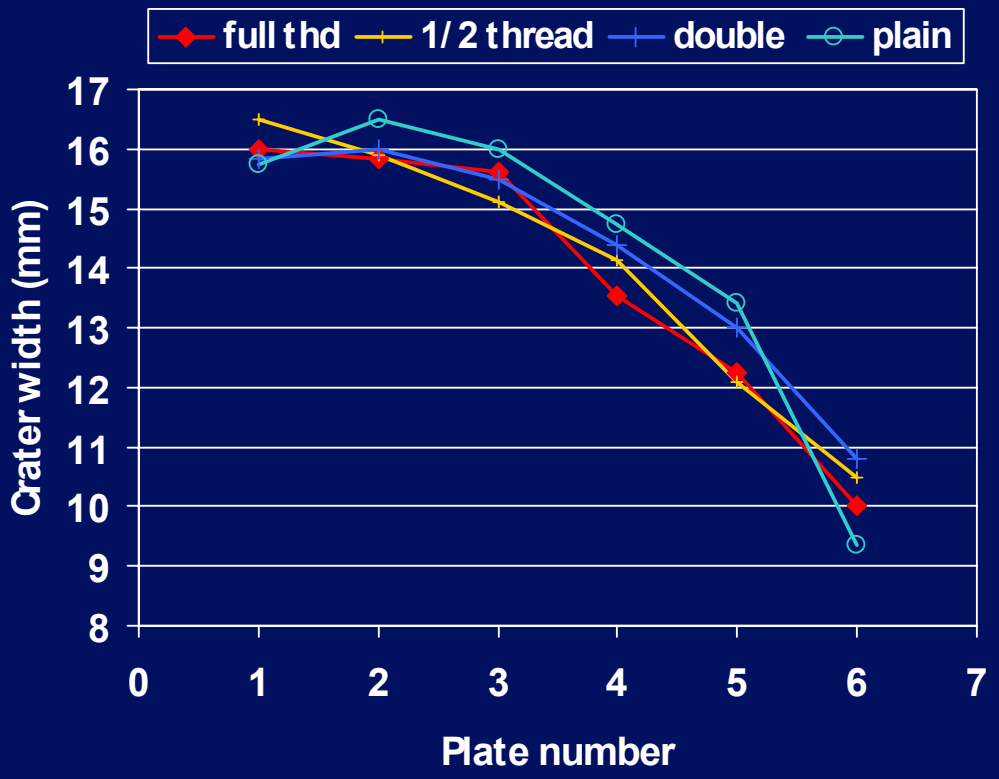
- Unthreaded rods with highest energy went no deeper than other designs
- 1615 m/s unthreaded rod has 5% greater KE than full thread design at 1633 m/s

- Impact pitch less than 0.5°
- All except one result perforated 6 plates
- Need to compare line of sight penetration



Average crater widths

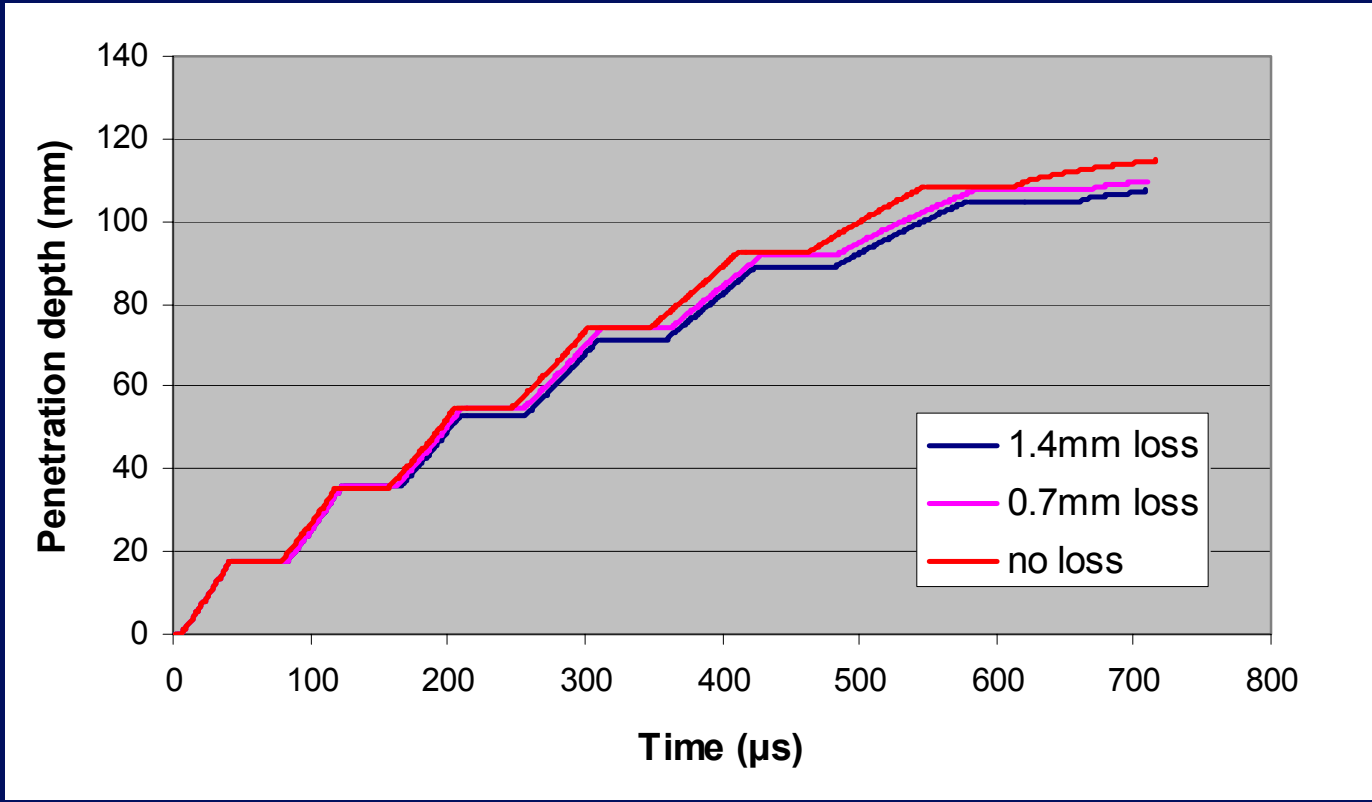
- Crater width reduces due to projectile deceleration
- Crater width for un-threaded rods increased from plate 1 to plate 2 – widest craters in most of the plates
- Full thread rod tends to have a narrower crater



How much change in penetration could be expected ?

- If the threaded rods lost one pitch per plate due to shear at break-out, what effect would this have on penetration ?
- This was assessed using an analytical penetration model, deleting part of the rod at plate exit
  - Nil deleted (plain rod)
  - 0.7mm deleted (standard thread)
  - 1.4mm deleted (double pitch)
- What effect could be expected just from the difference in effective rod diameter ?

Penetration vs. time for rod loss options

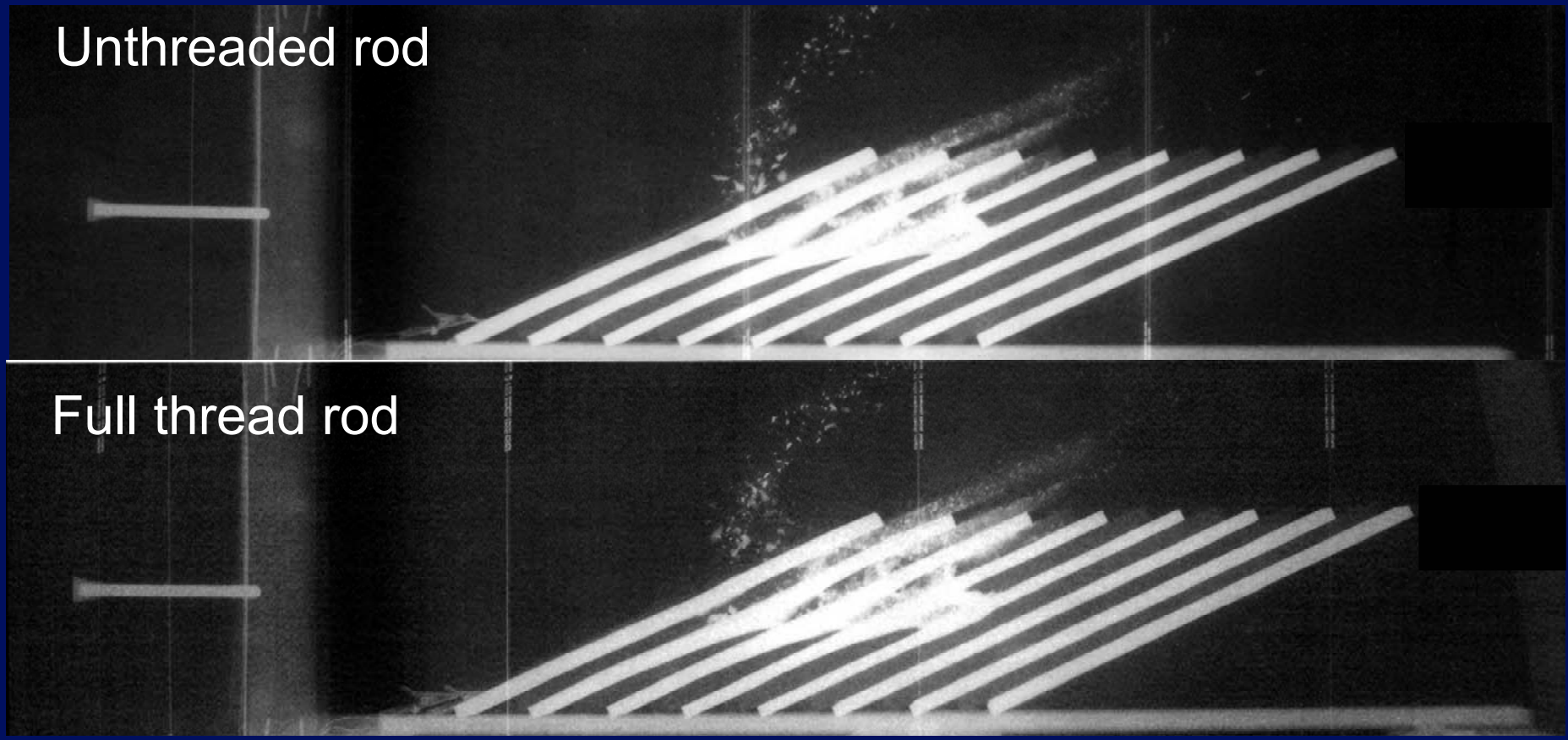


Predicted effect of rod loss

Rod type	Impact Velocity (m/s)	Rod diameter (mm)	Rod loss per plate (mm)	Total penetration (mm)
Unthreaded	1625	8	Nil	114
½ thread	1625	8		112 (interpolated)
Full thread	1625	8	0.7	110
Double thread	1625	8	1.4	106
Full thread	1625	7.70	Nil	112.85
Double thread	1625	7.77	Nil	112.8

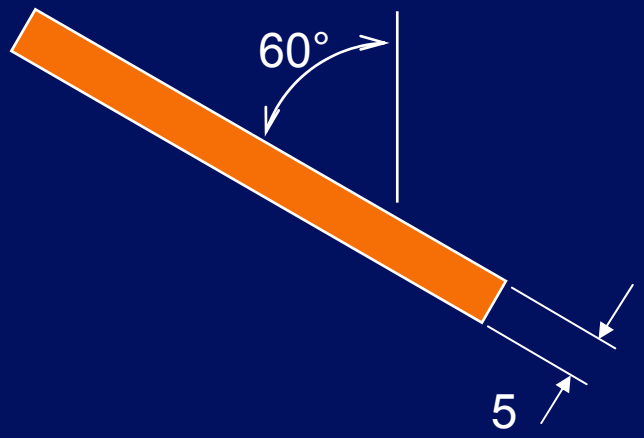
- 1.2 mm change in penetration predicted due to effective diameter
- 8 mm change in penetration predicted due to pitch loss
- 8 mm difference would be observed. No evidence that this is occurring

Comparison of X-rays - Target 2

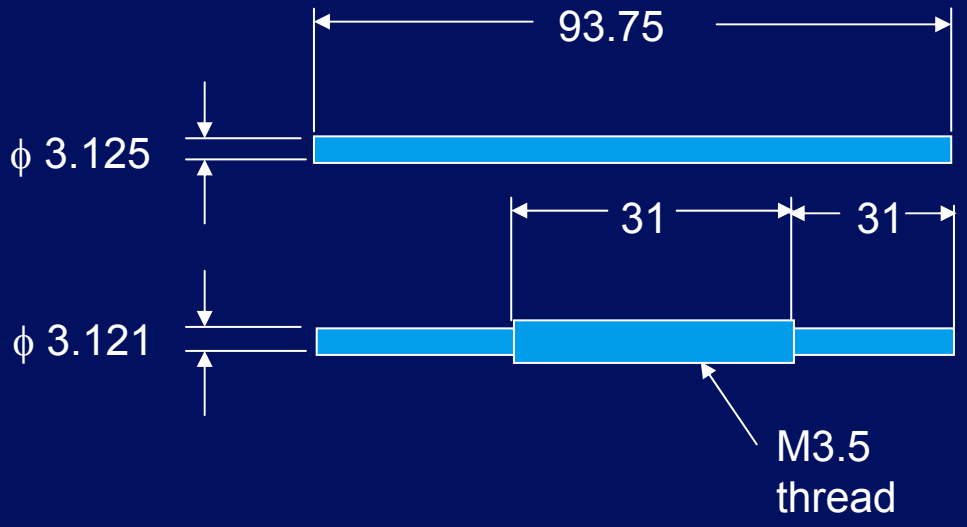


Reverse ballistic experiments

RHA target fired
at 1650 m/s



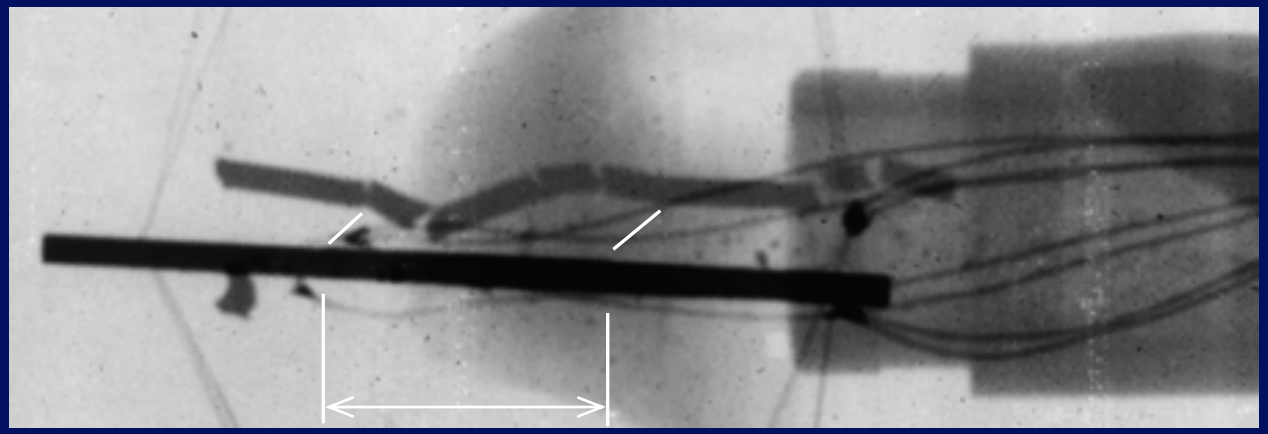
93% Tungsten alloy
projectiles



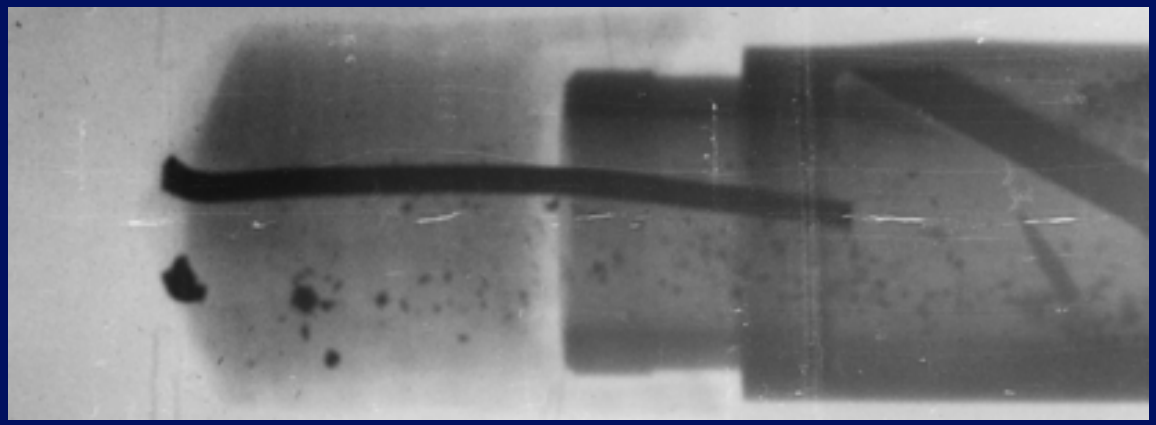
Projectiles pitched at 4°

Dimensions in
millimetres

Comparison of L/D 30 threaded vs. unthreaded



Threaded rod



Unthreaded rod

Conclusions

- Four variants of L/D 15 threaded penetrator showed no significant difference in penetration depths against two multiple plate targets
- In contrast there was a marked difference in the fracture behaviour of L/D 30 pitched attitude rods with and without threads
- Conclude that representing threaded rods with plain surfaces in simulations is valid for multiple plate targets but not for more disruptive targets

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